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Occupational Health in Ontario

Volume 7, Number 3, Summer 1986

Secondhand Tobacco Smoke Exposure in the Workplace

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Important Variables Controlling Exposure to Welding Fume

The Use of Pneumatic Hammers

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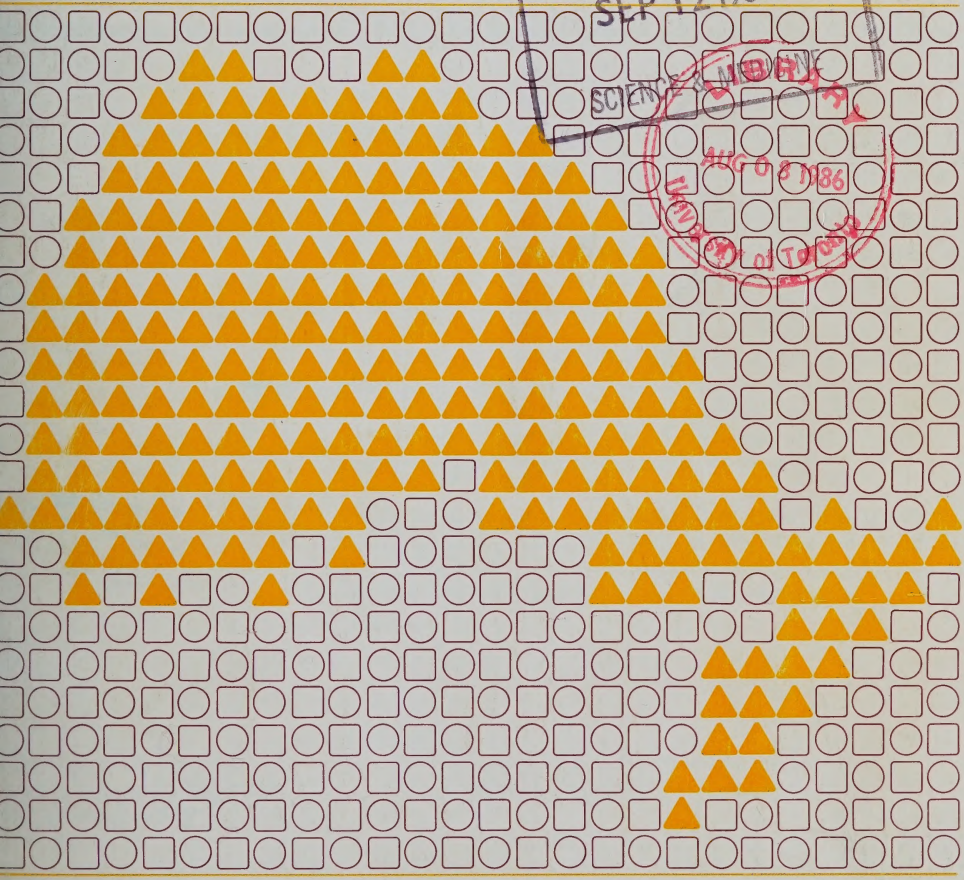

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Contents

R. House, M.D., C.M., D.I.H., C.C.B.O.M. — Secondhand Tobacco Smoke Exposure in the Workplace *118*

Thomas J. Robinson, M.Eng., C.I.H. — Important Variables Controlling Exposure to Welding Fume *134*

Lawrence DeSouza, M.B., B.S., C.I.H. — Occupational Health in India: Past, Present, Future *148*

Prof. Giovanni Loriga — The Use of Pneumatic Hammers *157*

Publications Available From the Government Book Store *162*

News and Notes *165*

Coming Events *166*

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Occupational Health in Ontario

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Secondhand Tobacco Smoke Exposure in the Workplace

Summary

In this paper the relative exposures to tobacco smoke constituents from passive versus active smoking are compared and the principal health effects associated with secondhand tobacco smoke are discussed. Exposure limits and control measures are considered. Procedural controls similar to those encouraged by the San Francisco Smoking Pollution Control Ordinance appear preferable to an approach based on measurement and control of specific tobacco smoke constituents in workroom air.

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Introduction

According to Collishaw and Mulligan,[1] Canada has the highest rate of cigarette consumption per capita of any industrial nation. The United States Department of Health and Human Services[2] estimated that, in 1980, smokers made up 34 per cent of the adult population in the United States. The average consumption per smoker was 22 cigarettes a day. Collishaw[3] stated that in Canada in 1981 both the percentage of smokers (39 per cent) and the average daily consumption of cigarettes per smoker (27) were higher than in the United States. He estimated that there were 7.4 million smokers in Canada in 1981 and a total yearly cigarette consumption of 74 billion cigarettes.

However, active smoking is not the only way in which one can be exposed to tobacco smoke. Involuntary (passive or secondhand) smoking is the result of the inhalation of combustion products of tobacco other than by directly puffing on a cigarette, cigar or pipe. Secondhand tobacco smoke is now being referred to increasingly in the medical and scientific literature as environmental tobacco smoke (ETS).

Repace and Lowery,[4] using American survey data on smoking patterns, have estimated that 86 per cent of nonsmokers are passively exposed to tobacco smoke in either the work or the home environment and sometimes in both. Because a higher percentage of Canadians than Americans smoke and because the consumption per smoker is greater in Canada, the probability of nonsmokers being exposed passively to tobacco smoke at work and/or at home, and the intensity of their exposure, would be expected to be at least as great in Canada as in the U.S.

The major health effects from active smoking – lung and other types of cancer, chronic obstructive lung disease, coronary artery disease – have been investigated in considerable detail, and a compilation of research was provided in the report by the U.S. Surgeon General[5] in 1979. However, concern about the health effects from passive smoking is comparatively recent. Given the large percentage of nonsmokers passively exposed to tobacco smoke at work and/or at home, the demonstration of

clinically important health effects in nonsmokers would constitute an important public and occupational health problem.

Exposure Conditions

Physiochemical Characteristics of Tobacco Smoke

Tobacco smoke consists of liquid particles dispersed in a gas medium. The particulate phase is defined as that portion of smoke retained by a Cambridge filter; the gas portion is composed of many organic and inorganic chemicals, and the particles vary in diameter from about 0.2 to 1.0 microns. Holbrook[6] in a recent review of the physiochemical characteristics of cigarette smoke, mentions that although cigarette smoke constituents are usually classified as being gaseous or particulate, individual constituents may be in either phase or they may exist in a distribution equilibrium, and hence be found in both phases.

Many factors influence the chemical composition of cigarette smoke, including the type of tobacco, the physical design of the cigarette and the smoker's puffing characteristics. During puffing, temperatures in the burning end of the cigarette reach 900°C, while the temperature at the butt end is near 30°C. The high temperature of combustion results in pyrolysis and pyrosynthesis and the generation of more than 3,800 identified chemicals in cigarette smoke.

Tobacco smoke can also be classified into two general categories – mainstream smoke and sidestream smoke. Mainstream smoke is the smoke that is drawn through the cigarette by active puffing. This mainstream smoke is filtered by the smoker's upper respiratory tract and lungs (if inhalation occurs) and is then exhaled into the general environment. Sidestream smoke arises from the burning end of the cigarette, cigar or pipe and enters directly into the environment. Sidestream and mainstream smoke differ in the concentration of various tobacco combustion products, due mainly to the temperature of combustion and the filtration by the cigarette. Most gas phase and particulate phase constituents are in higher concentration in sidestream smoke than in mainstream smoke. In particular, the concentrations of various human carcinogens such as 2-naphthylamine, aniline, benzo(a)pyrene and pyrene are greater in sidestream smoke than in mainstream smoke. Most (up to 85 per cent) of the smoke in a room results from sidestream smoke.

Relative Exposure to Tobacco Smoke Constituents from Passive Versus Active Smoking

The mainstream and sidestream concentrations of various tobacco smoke combustion products do not accurately reflect the true exposure of the involuntary smoker in comparison to the active smoker. The mainstream smoke inhaled by the active smoker enters the respiratory tract and lungs directly and is diluted only by the tidal volume of air breathed in by the smoker while inhaling. The mixture of approximately 85 per cent sidestream smoke and 15 per cent exhaled mainstream smoke, to which the passive smoker is exposed, is diluted in a much larger volume of air. Therefore, passive smoking results in a quantitatively smaller smoke exposure than active smoking.

The involuntary smoker's exposure is determined by the concentration of tobacco combustion products in the ambient air. The ambient concentration is influenced by many factors, including the size of the room, the ventilation rate, the percentage of fresh make-up air supplied, the number of smokers in the room, the total number of cigarettes smoked, the rate and manner of smoking and the type of cigarettes. Therefore, it is difficult to quantify the exposure to secondhand tobacco smoke accurately, although attempts have been made based on air sampling and biological monitoring.

Hugod *et al.*[7] measured the airborne concentration of various gas phase and particulate phase components in sidestream cigarette smoke. The smoke was generated by a smoking machine in a room with a volume of 68.1 m^3. Initially, 20 cigarettes were 'smoked' by machine for 10 minutes, resulting in an air concentration of carbon monoxide (CO) of 20 ppm. The CO concentration was kept at this level by the machine smoking of a further 30 cigarettes during a three-hour period. For each contaminant, the amount inhaled (mg/h) by passive exposure could be estimated by multiplying the airborne concentration of each contaminant by 0.4 (0.4 m^3 was taken to be the average volume of air inhaled by a man at rest during a one-hour period). This allowed the amount of each contaminant inhaled by active and passive smoking to be compared, and cigarette equivalents per hour (CE/h) and cigarette-equivalent-time (CET) to be calculated.

Cigarette equivalents per hour (CE/h) is a conventional way of expressing the amount of a particular component of tobacco smoke inhaled by a passive smoker during a

one-hour period relative to the amount of the same component inhaled by an active smoker from one cigarette. Cigarette-equivalent-time (CET) expresses the time in hours that it is necessary for a person to stay in a room containing secondhand tobacco smoke in order to inhale the same amount of each tobacco smoke constituent as the average cigarette smoker inhales from one cigarette.

The values of CE/h and CET obtained by Hugod *et al.* are presented in Table 1.

Table 1

Tobacco Smoke Constituent	Average Yield From Mainstream Smoke Inhaled by a Smoker (mg/cigarette)	Inhaled Amount by Passive Smoking (mg/h)	CE/h	CET
NO	0.30	0.182	0.61	1.6
CO	18.40	9.16	0.50	2.0
Aldehyde	0.81	0.21	0.26	3.8
Acrolein	0.09	0.01	0.14	7.1
TPM*	25.30	2.300	0.09	11.1
Nicotine	2.10	0.041	0.02	50.0
Cyanide	0.25	0.005	0.02	50.0

*Total Particulate Matter

The results indicate that an individual must be involuntarily exposed to secondhand cigarette smoke for two hours to inhale the same amount of CO as is inhaled by the active smoking of one cigarette; the corresponding figure for hydrogen cyanide is 50 hours. The large differences in CET and CE/h for different contaminants indicate the dependence of these estimates on the particular tobacco smoke constituent chosen for active/passive smoking comparison. Furthermore, comparison of CE/h or CET values based on air contaminants depends on the exposure conditions in a specific study, and this makes comparisons between studies difficult.

Several studies have attempted to use biological monitoring results, such as carboxyhemoglobin and urine nicotine, in passive smokers *vis-à-vis* active smokers to estimate the cigarette equivalents due to passive exposure to tobacco smoke for a specified time period. For example, Seppanen[8] studied the carboxyhemoglobin levels of nonsmokers passively exposed to cigarette smoke (carbon monoxide concentration of about 30 ppm)

and concluded that the mean increase of carboxyhemoglobin extrapolated over an eight-hour period would be approximately equivalent to the exposure obtained from actively smoking about five cigarettes. Feyerabend *et al.*[9] studied nicotine concentrations in the urine and saliva of 82 smokers and 56 nonsmokers after a morning at work. In this study the passive exposure occurred under actual work conditions during the morning of a typical working day. All nonsmokers were found to have measurable amounts of nicotine in both saliva and urine. The amount of nicotine absorbed by nonsmokers produced salivary and urinary concentrations similar to those found in light smokers. Light smokers were described as workers who had smoked up to three cigarettes in the three to four hours prior to the urine and saliva measurements. Foliart *et al.*[10] reported that passive absorption of nicotine from tobacco smoke by flight attendants during a transoceanic flight was roughly equivalent to absorption after smoking one cigarette.

The half-life of blood carboxyhemoglobin is approximately four hours. Thus, blood carboxy-hemoglobin is a useful biologic marker of recent exposure to secondhand tobacco smoke, but it cannot be used to assess long-term exposure. Similarly, the half-life of nicotine in the blood of smokers is quite short. Armitage *et al.*[11] found that the half-life of nicotine in arterial blood following inhalation ranged from 24 to 84 minutes, with a mean of about 40 minutes. Most of the absorbed nicotine is metabolized rapidly, the liver being the major site of detoxification; cotinine is the main metabolite of nicotine. Recently, cotinine has come to be considered a better marker of cigarette smoking than the parent alkaloid because it has a longer plasma half-life (about 30 hours) and reaches higher concentrations in plasma and urine, making identification easier. Also, cotinine is found in only trace amounts in tobacco smoke; this makes contamination of urine samples with exogenous cotinine very unlikely (in contrast to nicotine).

Matsukura *et al.*[12] measured urine cotinine levels in 392 smokers and 472 nonsmokers and examined the relationship between urinary cotinine excretion in the nonsmokers and the 'smokiness' of their environment. The urinary cotinine levels of nonsmokers who lived with smokers were higher than those of nonsmokers who did not, and increased with the combined daily cigarette consumption of smokers in the family. Nonsmokers who lived with smokers who smoked more than 40 cigarettes per day had urine cotinine levels (mean ± SEM of 1.56

± 0.57 μg per mg of creatinine) that were nearly identical to those of smokers of less than three cigarettes per day. The urinary cotinine values of nonsmokers who worked with smokers were also higher than those of nonsmokers who did not, and the urine cotinine values in nonsmokers increased with the number of smokers in the workplace.

These comparisons of various biological monitoring results in active and passive smokers indicate that passive exposure over an eight-hour workday in an office environment where many people smoke is probably comparable to light active smoking (i.e. about 1–5 cigarette equivalents). Therefore, some of the health effects anticipated in passive smokers might be estimated by extrapolation to low doses from dose-response or dose-effect curves for active smokers.

Health Effects

The principal health effects that have been reported to be associated with passive exposure to tobacco smoke include:

1) irritation of the eyes, nose and throat and the general annoyance associated with these irritant symptoms;
2) exacerbation of pre-existing diseases, especially allergic rhinitis, asthma and angina;
3) respiratory symptoms such as cough; increased rates of upper and lower respiratory tract infections and decrements in pulmonary function tests in children exposed to tobacco smoke due to their parents' smoking habits;
4) pulmonary function test changes in adults ($FEF_{25-75\ per\ cent}$ and $FEF_{75-85\ per\ cent}$); these changes are indicative of early small airways impairments;
5) lung cancer.

There is little doubt about the irritating and annoying effects of secondhand tobacco smoke. A higher percentage of nonsmokers than smokers is annoyed by cigarette smoke. For example, Donahue and Capshaw,[13] in a survey of 9,415 individuals in Pennsylvania, found that 73 per cent of nonsmokers, 66 per cent of ex-smokers and 41 per cent of smokers were bothered by tobacco smoke in indoor air. The most frequent irritant symptom reported from exposure to secondhand smoke is usually eye irritation. In a survey by Speer[14] this symptom was reported in 69.2 per cent of nonallergenic individuals. The evidence also appears quite convincing

for the exacerbation of the symptoms of some diseases due to passive smoking, especially allergic rhinitis,[15,16] asthma[16,17] and angina pectoris.[18] Similarly, as summarized by Weiss *et al.*,[19] the evidence indicates that, in children, increased frequency of pulmonary symptoms, such as chronic cough, and increased rates of acute respiratory infection as well as decrements in various pulmonary function tests are associated with exposure to parental (mainly maternal) smoking.

The existing research on changes in pulmonary function tests ($FEF_{25-75\ per\ cent}$ and $FEF_{75-85\ per\ cent}$) indicative of small airways impairment in adults exposed passively to cigarette smoke for many years is more equivocal, but seems, on balance, to favour the occurrence of such changes. Of three key studies that have investigated the relation between secondhand tobacco smoke exposure and such pulmonary function test changes, two have demonstrated an association (White and Froeb[20] and Kauffman *et al.*[21]) and one has not (Kentner *et al.*,[22]). All three studies utilized an essentially similar design – that of the cross-sectional analytic survey. As such, none of the studies was truly prospective. Also, Comstock *et al.*[23] and Shilling *et al.*[24] did not find a statistically significant association between secondhand tobacco smoke exposure in the home and decrement in pulmonary function tests. However, Shilling *et al.*[24] and Comstock *et al.*[23] considered only FEV_1; indeed, Comstock *et al.*[23] used a qualitative variable derived from FEV_1, which was even less sensitive than FEV_1 in terms of detecting early small airways impairment ($FEF_{25-75\ per\ cent}$ and $FEF_{75-85\ per\ cent}$ are more sensitive indicators than FEV_1 or FVC of early small airways impairment). Also, it should be emphasized that the changes in flow rates associated with involuntary smoking in the studies by Kauffmann *et al.*[21] and White and Froeb[20] are quite small and are not considered indicative of serious disease. Hence it is important to note the distinction between the statistical significance and the clinical significance of the changes in pulmonary function thought to be associated with passive smoke exposure.

The question of whether cancer, especially lung cancer, is caused by involuntary exposure to tobacco smoke has been intensely investigated since Hirayama[25] first reported this association. He carried out a prospective study in Japan over a 14-year period (January 1966–December 1979) in which lung cancer mortality rates in 91,540 nonsmoking women were compared according to the smoking habits of their husbands.

The lung cancer mortality rates standardized by age and occupation were 8.7/100,000 for women with nonsmoking husbands, 14.0/100,000 for women whose husbands were ex-smokers or smoked 1–19 cigarettes per day and 18.1/100,000 for women whose husbands smoked 20 or more cigarettes per day; the corresponding relative risks of lung cancer for women whose husbands were in these smoking categories compared to women with non-smoking husbands were 1.00, 1.61 and 2.08 respectively. This increase in the relative risk of lung cancer in nonsmoking women as the cigarette consumption of their husbands increased was statistically significant ($p = 0.00097$).

The results of the study by Hirayama have stimulated further research to investigate the association between passive smoking and cancer. Aside from the large prospective study by Garfinkel,[26] which involved a re-analysis of data collected over a 12-year period by the American Cancer Society (and did not corroborate Hirayama's findings), these recent studies have utilized mainly a case-control design.

Of the twelve studies reviewed (Hirayama,[25] Garfinkel,[26] Trichopoulos *et al.*,[27] Correa *et al.*,[28] Chan and Fung,[29] Koo *et al.*,[30] Gilles *et al.*,[21] Miller,[32] Kabat and Wynder,[33] and Sandler *et al.*,[34–36] the majority found an association between passive smoking and lung cancer, although, in some cases, multiple subgroup analysis was required to demonstrate an association (e.g. Kabat and Wynder[33]), and, in others, overall cancer was considered rather than lung cancer (Sandler *et al.*[34–36]). Also, a publication bias (Pocock,[37]) tends to favour publication of studies that find an association over those that do not, especially studies of very topical issues. This type of bias may be operative in the reporting and publishing of passive smoking studies. However, the studies reviewed appear to show overall consistency of an association between lung cancer and passive smoking, and hence suggest that lung cancer is caused by long-term exposure to secondhand tobacco smoke. This conclusion is also biologically plausible given the proven association between lung cancer and active smoking, the demonstrated presence of several carcinogens, including lung carcinogens, in sidestream tobacco smoke and the general acceptance that the risk of lung cancer is directly related to the amount of tobacco smoke inhaled.

Relation Between the Health Effects and the Health Hazard Due to Secondhand Tobacco Smoke in the Workplace

Therefore, various health effects have been found to be related to involuntary exposure to tobacco smoke. Usually, the demonstration of these health effects has been obtained from studies in which individuals were definitely exposed to high levels of environmental tobacco smoke. Indeed, the identification of such a cohort of exposed individuals improves the efficiency (and statistical power) of the study to show a particular health effect due to environmental tobacco smoke. However, these exposure conditions result in a trade-off between the efficiency of the study and the generalizability of its results to other individuals exposed to lower levels of environmental tobacco smoke.

The health hazard to an individual or a group of individuals in a particular work environment obviously depends on the particular exposure conditions. As described previously, these exposure conditions are a function of a number of factors, such as the size of the room, the ventilation rate, the percentage of fresh make-up air supplied, the number of smokers in the room, the total number of cigarettes smoked, the rate and manner of smoking and the type of cigarettes. Therefore, it is difficult to quantify accurately the health hazard in a particular workplace or for a particular individual.

Proposed Exposure Limits and Control Measures

Unfortunately, there is no chemical constituent that can be easily used as a marker or index to allow accurate and reliable assessment of the health hazard due to secondhand tobacco smoke exposure in the occupational environment. However, several different exposure limits and other control strategies have been proposed for environmental tobacco smoke.

Muramatsu *et al.*[38] recommended a Δ CO concentration of 1.5 ppm to minimize irritant effects from passive exposure to cigarette smoke. This Δ CO concentration represents the change in carbon monoxide concentration in an office environment due to occupancy of the room and to smoking by the occupants. Although carbon monoxide is not itself an irritant, Muramatsu *et al.*[38] have shown that Δ CO is a good predictor of irritant symptoms. However, the Δ CO or CO concentration is not specific for cigarette smoke, and there can be practical difficulties with the accuracy and precision of measuring small values of Δ CO such as 1.5 ppm.

Repace and Lowery[4] have proposed a standard for tobacco smoke respirable suspended particulate (RSP) on the basis of a risk assessment intended to reduce the risk of lung cancer from passive smoking to an 'acceptable' level. The exposure information was obtained from their own data on measured air levels of particulate in the home and work (office) environments and home/office time-use survey data; the response information was obtained from the results of the Hirayama lung cancer study described previously and lung cancer mortality data from Seventh Day Adventists in the U.S. The proposed standard of 0.75 $\mu g/m^3$ RSP for an annual average eight-hour daily workplace exposure is based on limiting the risk of lung cancer in a nonsmoker to 1 per 100,000 for a 40-year working life. Repace and Lowery[4] estimate that the actual concentration of tobacco particulate in a typical office where smoking is permitted is about 200 $\mu g/m^3$ (267 times their proposed standard).

Compliance with these Δ CO, RSP and/or other exposure limits for tobacco smoke in the work environment could be achieved in theory by general ventilation. However, attempts to control tobacco smoke exposure by general ventilation are not cost-effective and require ventilation rates far in excess of the usual ventilation rates in an office environment. For example, Lederer *et al.*[39] have estimated that to reduce tobacco smoke particulate concentrations in a 10 by 15 foot office occupied by a chain-smoker and a nonsmoker, even to within limits prescribed by the EPA National Ambient Air Quality Standard (75 $\mu g/m^3$ total suspended particulate), would require in excess of 30 air changes per hour. It should be noted that the EPA standard for total suspended particulate of 75 $\mu g/m^3$ as an annual geometric mean is still about 100 times higher than the standard proposed by Repace and Lowery[4] for tobacco smoke particulate of 0.75 $\mu g/m^3$. Currently, air-exchange rates in new residences are in the range of about 0.5 to 1.0 air exchanges per hour, and some energy efficient residences have air-exchange rates of the order of 0.3 to 0.5 air exchanges per hour. Therefore, an emphasis on general ventilation to control tobacco smoke contaminants in office environments would require large increases in ventilation, and this would be contrary to efforts to increase energy-efficiency by reducing natural and mechanical general ventilation. However, such reduced general ventilation should also not be encouraged because, irrespective of secondhand tobacco smoke exposure, such poor ventilation results in the well

publicized sealed building syndrome (SBS), in which the occupants experience symptoms such as headache, drowsiness, general malaise, eye and upper respiratory tract irritation and skin rashes.

Ventilation guidelines in an indoor environment have been established by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). In an office where smoking is permitted, ASHRAE recommends no less than 20 cfm of make-up air per occupant. If no smokers are present, the recommended minimum volume of make-up air is 5 cfm per occupant. However, ASHRAE's design ventilation rates for tobacco smoke have been criticized as inadequate to control not only odour but also total suspended particulate to within the EPA National Ambient Air Quality Standard. Repace and Lowery[40] have also estimated that current ASHRAE ventilation rates prescribed for office buildings whose ventilation systems are designed for smoking would still expose a nonsmoker to the inhalation of the equivalent of about $2^1/_2$ cigarettes per eight-hour workshift.

Since general ventilation is not a cost-effective means of reducing passive exposure to tobacco smoke, more effective alternative means of control should be examined. These are referred to as administrative or procedural controls, and might include, for example, segregation of smokers and nonsmokers and restriction or elimination of smoking in the work environment.

A number of Ontario municipalities have already introduced, or are contemplating, legislation to control smoking in public places. Previous public surveys in Ontario by Shephard and LaBarre[41,42] have indicated that the majority of both smokers and nonsmokers favour such restriction of smoking.

Hence the accumulation of evidence concerning the health effects of passive smoking plus the survey data indicating the desire of the public for restriction of smoking provide a basis for action. An appropriate legislative model might incorporate elements of the Smoking Pollution Control Ordinance of San Francisco.[43] This ordinance, which went into effect on March 1, 1984, requires employers to 'accommodate, insofar as possible, the preferences of nonsmokers and smokers, and, if satisfactory accommodation cannot be reached, to prohibit smoking in the office workplace.' Consistent with this ordinance, it is recommended that the control of secondhand tobacco smoke exposure in the office workplace should be based on an employer-employee

assessment of the health hazard due to passive smoking in each work environment and the development of a control program based largely on procedural control. However, if a dispute persists and resolution is required, the requests of nonsmokers should take precedence over those of smokers, and, if necessary should result in the prohibition of smoking in the workplace.

Résumé

Dans cet article, on compare les effets de l'exposition aux éléments constitutifs de la fumée de cigarette sur le fumeur lui-même et sur celui qui est exposé à la fumée des autres, et on examine également les principaux effets de la fumée des autres sur la santé. Les mesures de surveillance et les seuils limites quant à l'exposition sont également étudiés. Il semble préférable d'avoir recours à des méthodes semblables à celles que favorise l'ordonnance de San Francisco sur le contrôle de la pollution par la fumée de cigarette plutôt que d'employer des méthodes de mesure et de surveillance des éléments constitutifs de la fumée de cigarette dans l'air ambiant en milieu de travail.

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Important Variables Controlling Exposure to Welding Fume

Summary

There are over 80 welding and cutting processes, over 30 harmful agents and a variety of work area and operator variables. These may be ranked by considering information on contaminant generation rates, frequency of use and the consequences of overexposure. This analysis shows that there are significant opportunities for some welders to be exposed to hazardous fumes from certain processes, base metals and coatings. However, most welding is done on uncoated mild steel in unconfined work areas, using shielded metal arc welding, gas metal arc welding or oxyfuel gas cutting.

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Introduction

To identify the important variables controlling exposure to welding fume, it is useful to categorize them by considering four descriptive features of the workplace: process, harmful agents, work area and operator.

Industry experience and applications can then be reviewed to determine how often these important variables come into play. This information on frequency of use will help to produce a short list of important variables according to the four categories as follows:

1) *Processes* presenting the greatest opportunity for hazards based on frequency of use and contaminant generation rates.
2) *Harmful agents* presenting the greatest potential for hazards based on frequency of use and consequences of overexposure.
3) The *work area* variables of greatest importance in determining exposure.
4) The *operator* variables of greatest importance in determining exposure.

This approach was used to study the character and extent of welding hazards in Ontario industry for the Ontario Ministry of Labour.[1]

Welding and Cutting Processes

There are over 80 welding and cutting processes recognized by the American Welding Society,[2] but this large number can be reduced by considering two characteristics that determine the degree of hazard:

1) contaminant generation rates
2) frequency of use

Contaminant Generation Rates

The amount of fume produced by welding processes is usually expressed as the fume generation rate (FGR) in grams of fume per minute (g/min). Table 1 provides a short list of common processes ranked according to their ability to generate fumes. As an example, compare the FGR for gas metal arc welding of steel with the FGR for flux cored arc welding of steel. There is a possible sixfold difference, which will have a significant effect on exposure levels. This is an important observation since gas metal arc welding may be replaced by flux cored arc welding when greater metal deposition rates are required.

Table 1 **Ranges of Fume Generation Rates**

Process	Material	FGR (g/min)
Arc Air Gouging	Steel	1.4 – ?
Flux Cored Arc Welding	Steel	.9 – 3.1
Shielded Metal Arc Welding	Steel	.3 – .8
Oxyfuel Gas Cutting	Steel	.2 – .7
Gas Metal Arc Welding	Steel	.2 – .5
Gas Tungsten Arc Welding	Steel	.003 – .007
Submerged Arc Welding	Steel	.003 – .006

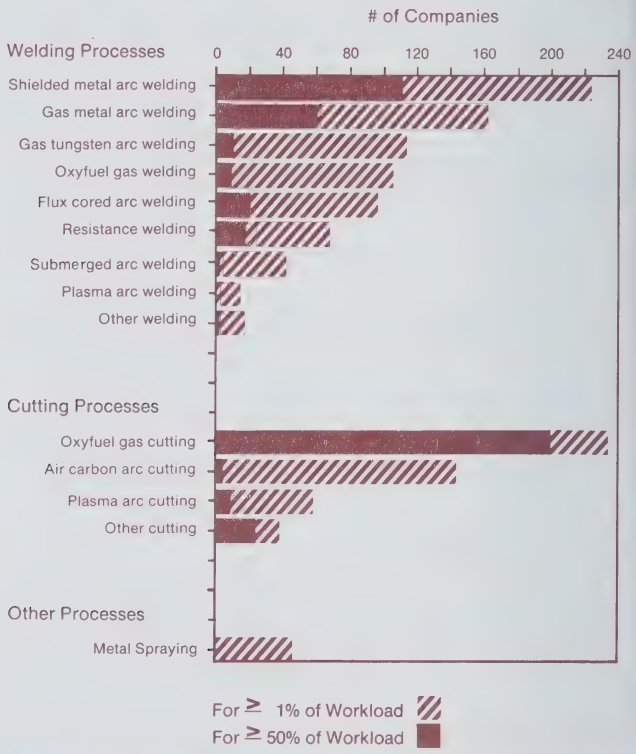
Once a process with a characteristic range of emissions has been chosen, a number of variables come into play that determine what the actual emission rate will be. Given a specific combination of process, electrode, flux and/or shielding gas, there are three principal factors that influence fume generation rates: current, voltage and polarity. Physical factors such as electrode size, humidity, electrode inclination, arc length, current density, melting rate and power input have also been investigated. These factors may contribute to increases in fume generation rate of up to 50 per cent. Electrodes of the same type from different manufacturers may differ by a factor of two in fume generation rates.

Frequency of Process Use

Many types of welding do not find wide use in the industrial sectors that employ the majority of welders. A questionnaire survey in 1984 produced information on the welding processes used by 259 responding companies.[1]

Figure 1 shows that many welding and cutting processes may be found in use, but shielded metal arc welding, gas metal arc welding and oxyfuel gas cutting are the processes with the greatest application.

Figure 1 **Process Used by 259 Responding Companies**



Harmful Agents Associated with Welding

Over 30 harmful agents can be created during welding, depending on the process, base metal, surface treatment and consumable. These airborne contaminants are usually produced by processes with an open arc or flame. Consumable welding materials are more likely to vaporize and form a fume than is the base metal; however, consideration of the base metal and surface treatment will often give a good indication of the harmful agents to be expected.[3]

Base metals may be divided into four main categories: ferrous, aluminum, nickel or copper alloys. There are seven surface treatments of interest: painted, galvanized,

degreased, electroplated, metal sprayed, plastic coated and chemical contamination.

The large number of harmful agents associated with these base metals and coatings may be reduced by considering two characteristics that determine the degree of hazard.

1) consequences of overexposure to the harmful agent;
2) frequency of use of the base metal associated with the harmful agent.

Consequences of Overexposure

The following harmful agents, which present the greatest potential hazards to welders, are ranked according to the health consequences of exposure.[4]

Chromium – carcinogen in other industries and potential for excessive exposure in welding of stainless steel.

Nickel – carcinogen in other industries and potential for excessive exposure in welding of stainless steel and nickel based metals.

Ozone – severe respiratory irritant; difficult to control; potential for excessive exposure in welding of aluminum alloys and stainless steel by gas metal arc welding and gas tungsten arc welding.

Oxides of Nitrogen – delayed pulmonary oedema; oxides of nitrogen can build up in confined spaces; potential for excessive exposure from oxyfuel gas cutting.

Fluorides – mucous membrane irritation; potential for exposure from low hydrogen or alkaline flux used in shielded metal arc welding and flux cored arc welding.

Manganese – acute respiratory problems and chronic nervous system disorder; potential for excessive exposure during hardfacing welding with high manganese alloys.

Phosgene – respiratory irritation and pulmonary oedema; delayed onset of symptoms; potential for excessive exposure during arc welding in work area or on workpieces contaminated with chlorinated hydrocarbon degreasing solvents.

Zinc – metal fume fever, pulmonary oedema and pneumonia; effects are usually temporary; potential for

excessive exposure in welding and cutting of galvanized steel.

Copper – metal fume fever and respiratory irritation; potential exposure when welding with copper base metal and consumable; excessive exposure less likely in any ferrous welding even when using copper coated gas metal arc welding wire.

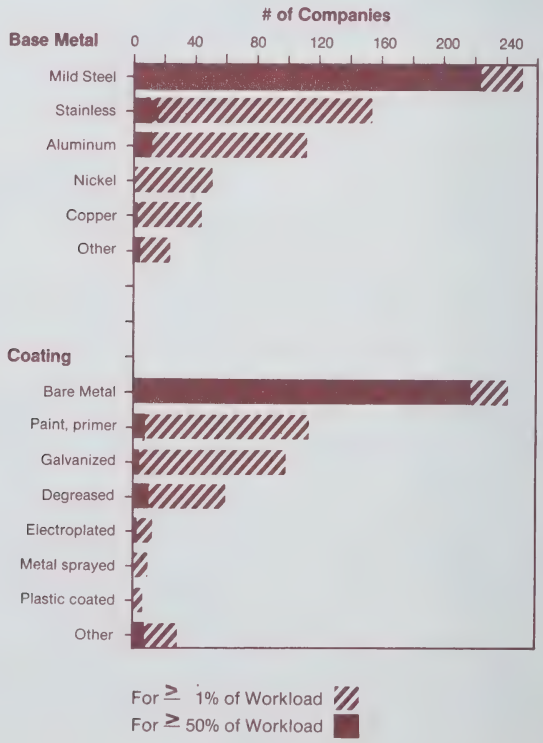
Barium – nervous disorders; effect on cardiac, arterial and skeletal muscles; potential for exposure when present in the flux for cast iron.

Frequency of Use of Base Metal

The frequency of use of a base metal (and its associated harmful agents) depends on its application in industry. There are many metal alloys that can be welded, but relatively few find wide use.

Figure 2

Base Metals and Coatings Used by 259 Responding Companies



In the 1984 questionnaire survey, companies were asked to identify the base metals welded in their plant, including the use of coated or surface-treated metal (e.g. galvanized, painted).

Figure 2 demonstrates that a wide variety of metals and coatings, which can be significant sources of hazardous welding fumes and gases, are used by substantial numbers of companies.

However, Figure 2 also puts the use of these hazardous base metals and coatings into perspective by demonstrating that most of the responding companies do 50 per cent or more of their welding on mild steel and bare metal.

Effect of the Work Area

The variables in the work area that can affect welder exposure are:

1) degree of confinement (open, enclosed, confined);
2) use of ventilation;
3) workpiece configuration.

The significance of these variables can be determined by looking at the results of surveys that have studied their effect and by considering the frequency with which they come into play in the industrial setting.

The effect of confinement is one of the few variables that breathing zone sampling can detect in spite of the great variability in sample results from welding fume surveys. For example, with 209 samples taken in a shipyard, Akbarkhanzadeh[5] found the average total fume level in open locations to be 3.5 mg/m^3, significantly lower than the 5.9 mg/m^3 found in confined locations.

The use of ventilation is a factor that can also have a significant effect on exposure level. For example, Douglas and Plummer[6] measured breathing zone concentrations for welders in a shipyard, with and without local exhaust. Table 2 shows the reduction of concentration obtained in several samples of welding in confined and enclosed areas. Wright[7] measured operator exposure during flux cored arc welding, with and without the use of gun mounted local exhaust, and showed that substantial reductions of breathing zone concentrations were achieved. An investigation conducted by NIOSH[8] on the effectiveness of welding gun exhaust systems for gas metal arc welding found reductions in fume concentrations of 50 per cent.

Table 2

Breathing Zone Concentrations of Iron Oxide Welding Fume With and Without Local Exhaust[6]

Sample	Base Metal and Coating	With (mg/m^3)	Without (mg/m^3)
1	Mild steel, primed	4	8
2	Mild steel, primed	6	14
3	Mild steel, primed	8.4	16.5
4	Mild steel, primed	3.9	9.6
5	Mild steel, primed	8.9	12.3
6	Mild steel, primed	4.1	17.2
7	Mild steel, galvanized	2.7	9.6

The major contribution of the workpiece is to dictate the welding process and filler metal that must be used. However, the size and shape of the workpiece affects the position of the welder in relation to the weld and it also affects the type of ventilation that may be used to control the fume. For example, small components amenable to manual handling can be positioned readily in jigs or on benches that incorporate fixed exhaust ducts. In contrast, large fabrications, such as pressure vessels, demand flexibility and mobility from the welder, and the application of control techniques requires individual study. In some cases, the workpiece is so large that it becomes the work area (ship building).

Frequency of Application of Work Area Variables

In the 1984 questionnaire survey companies were asked to identify the percentage of welding or cutting done in three types of work areas; these were defined according to the degree of confinement as follows:

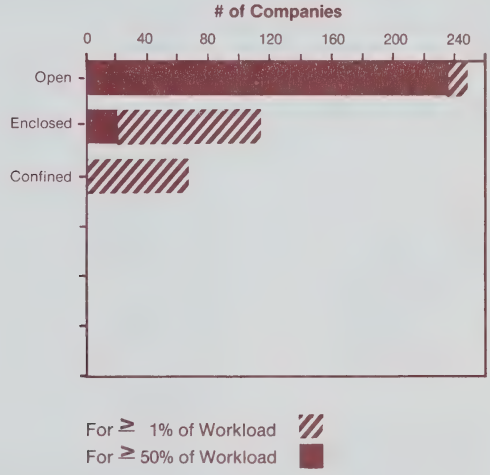
Open
- large workshop with unobstructed airflow
- outside
- fume is free to rise and escape

Enclosed
- compartments larger than about 2,000 cu.ft., with one side open to shop
- inside large fabrications
- fume is hindered from rising and escaping

Confined
- closed compartment less than about 2,000 cu.ft.
- accessible through manhole
- fume is prevented from rising and escaping

The opportunity exists among the 259 responding companies for the degree of confinement to have an effect on welder exposure; however, Figure 3 shows that very few companies do large amounts of enclosed or confined welding/cutting. Most companies do 50 per cent or more of their welding/cutting in open areas.

Figure 3 **Degree of Welder Confinement Used by 259 Responding Companies**



Most of the 259 responding companies rely on natural (88 per cent) and general (77 per cent) ventilation to some extent for control of fumes and gases in general workshop air. The usage of overhead, electrostatic precipitators (31 per cent) is worth noting since their mounting position above the welder does nothing to reduce breathing zone fume concentrations. Local exhaust points are used in 61 per cent of the responding companies.

An effort was made to correlate local exhaust use with other variables considered to have a positive effect on the need for, or use of, local exhaust. The results are displayed in Table 3.

Table 3 **Correlation of Local Exhaust Use with Other Variables**

Variable	Number of Companies	Percentage of These Companies Using Local Exhaust
All companies	259	61%
Companies doing 10% or more stainless steel welding	75	67%
Companies doing 10% or more galvanized metal welding	25	84%
Companies with 10% or more confined space welding	27	85%

For example, local exhaust should be used for welding galvanized metal or for confined space welding. Companies doing more than 10 per cent of their welding/cutting under these conditions were found to use more local exhaust (84 to 85 per cent) when compared to the baseline value of 61 per cent usage in all responding companies. Also note the 67 per cent usage of local exhaust in companies doing 10 per cent or more stainless steel welding. This value is much lower than the 84 per cent usage associated with galvanized metal and may indicate that obvious, acute health effects (e.g. metal fume fever) are more likely to cause concern in the welding workplace than are possible, delayed health effects (e.g. cancer).

Effect of the Operator

The welder is the human factor in any welding situation and, not surprisingly, he is the single largest source of variability in the exposure level he experiences. This fact has been observed and evaluated subjectively by many researchers. Although it is a difficult parameter to quantify, several researchers have made the attempt.

Evans[9] measured breathing zone fume concentrations in a population of 25 welders performing the same welding task under nominally identical conditions. The results ranged from 1 to 28 mg/m^3, and the difference between welders was so great that no single day or part of a day out of the 25 days during which the study was conducted could have been taken to be representative of the exposure.

The Welding Institute of Cambridge[3] undertook a similar study and found that breathing zone concentration measurements ranged from 2 to 51 mg/m^3. The researchers felt that the only possible overall conclusion was that it is almost impossible to predict breathing zone fume concentration when an electrode of known fume generation rate is used by different welders in a site with known ventilation conditions. The individual welder, the welder's posture and the welding position appeared to have the most significant effects.

Welding Position and Welder Posture

Many researchers have noted in a qualitative way that some welders simply work in the fume plume and others do not. Relatively minor movements away from the plume can result in significantly lower breathing zone concentrations. Suspecting that welding position (hand position) and welder posture (body position) control the head-plume relationship, some researchers have tried to evaluate these variables (See Table 4).

Table 4

Position and Posture

Welding Position	Welding Posture
flat, downhand	crouching, kneeling
horizontal-vertical	sitting
overhead	standing

Using only one welder, and holding all other factors constant, the Welding Institute of Cambridge[3] made comparative tests on the effect of welding position. The flat, downhand position was associated with the highest breathing zone concentrations. No statistical significance was calculated for the results.

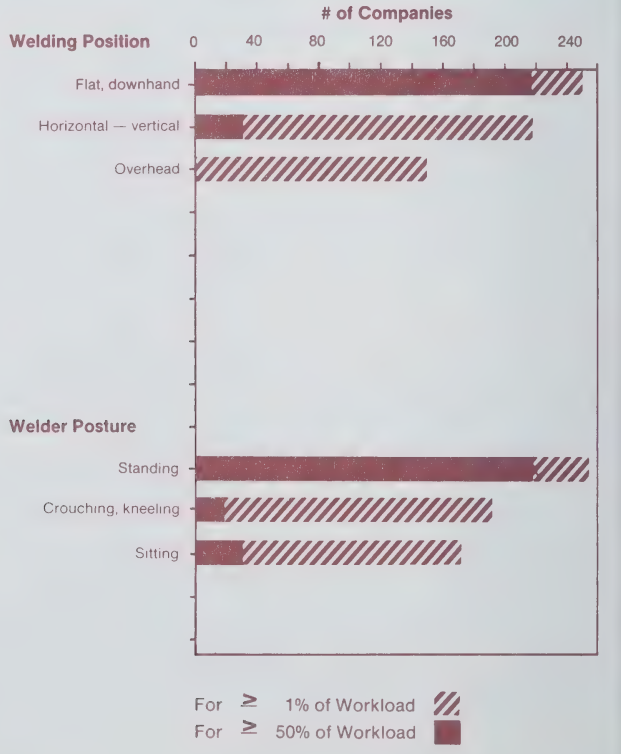
Akbarkhanzadeh[5] looked at the effect of posture, rationalized into two poses, on 209 shipyard welder breathing zone samples. He did calculate statistical significance and found that sitting or kneeling (taken together as one category) produced an average of 5.3 mg/m^3 total fume as opposed to 3.1 mg/m^3 total fume when standing.

Ulfvarson[10] looked at the effect of posture on measurements taken during welding of mild steel in a variety of workplaces. Analysis of variance revealed no influence due to welder posture in this study.

Frequency of Application of Operator Variables

In the 1984 questionnaire survey companies were asked to indicate the approximate percentage of welding and cutting done in the various welding positions and welder postures. Figure 4 shows that a variety of welding positions and welder postures are used in many responding companies. However, in over 80 per cent of responding companies the flat, downhand welding position is used and the standing posture is used for 50 per cent or more of their workload. The significance of this result is not clear, given the opposing views in the literature on the effect of posture. However, this combination of position and posture tends to place the welder's head above the source of hot, buoyant fumes, and breathing zone concentrations of fume would tend to be higher than if, for example, the welder was sitting beside a workpiece welding on a vertical surface at face level.

Figure 4 **Welding Position and Welder Posture Used in 259 Responding Companies**



Hazards to Welders

By considering the ranking of processes according to fume generation rate and the ranking of harmful agents according to consequence of overexposure, it is possible to describe and analyse welding situtions that can be expected to present the greatest hazard to welders:

a) shielded metal arc welding of stainless steel;
b) gas metal arc welding of stainless steel;
c) flux cored arc welding of mild steel;
d) air carbon arc/plasma arc cutting of galvanized steel.

Exposure levels may be aggravated in these and other situations by variables such as degree of confinement, inadequate ventilation and welder posture. Worst case scenarios can easily be imagined. For example, air carbon arc cutting (arc air gouging) of stainless steel in a confined space without adequate ventilation will produce very high exposure levels of iron, chromium and nickel.

By considering data on the frequency of use it is clear that there are significant opportunities for some welders to be exposed to hazardous fumes from certain processes, base metals and coatings. Exposure to these fumes may be exacerbated by confined work areas, poor ventilation and workpieces that make it difficult for the welder to keep his head out of the plume. However, it is also clear that, in the great majority of cases, more than 50 per cent of welding and cutting is done on uncoated mild steel, in open work areas, using either shielded metal arc welding, gas metal arc welding or oxyfuel gas cutting. This combination of variables is one of the least hazardous that can be defined for a welding workplace and helps to put concerns about welding fume into proper perspective.

Conclusions

1) Out of a list of over 80 welding and cutting processes, only a small number need to be considered after looking at contaminant generation rates and frequency of use. Most welding is done with shielded metal arc welding and gas metal arc welding.

2) Out of a list of over 30 harmful agents, arising from four classes of metal alloys and seven types of coatings, only a small number need to be considered after looking at the consequences of overexposure and frequency of use. Most welding is done on uncoated, mild steel.

3) The most important work area variables are the degree of confinement and the use of ventilation. Most welding is done in unconfined work areas.

4) The most important operator variable is the head-plume relationship, but it is not clear how this is affected by welder posture. Most operators weld in the flat, downhand position while standing over their work.

5) Local ventilation appears to have the greatest potential for controlling fumes from welding and cutting processes if it can be applied properly in a given welding situation.

6) The welding engineer can help to control exposure levels by considering, in the design of a product, the variables that the welder must work with: process, consumables, degree of confinement, applicability of local ventilation, welding position and posture.

7) Since the welding operator has some control over his own exposure, training in welding should include instruction on welding fume hazards and steps that the welder can take to control them.

Résumé

On a relevé plus de 80 méthodes de découpage et de soudage, plus de 30 agents nocifs et diverses variables relativement aux milieux de travail et aux opérateurs. On peut les classer en tenant compte de renseignements portant sur le taux de production de polluants, la fréquence d'utilisation et les conséquences d'une exposition excessive. La présente analyse démontre que certains soudeurs risquent en un grand nombre d'occasions d'être exposés à des vapeurs dangereuses en raison de l'emploi de certains procédés, métaux de base et enduits. Dans la majorité des cas, la soudure s'effectue sur de l'acier doux nu, dans des aires non fermées, au moyen de soudage avec électrodes enrobées, de soudage à l'arc métallique sous gaz inerte ou de découpage par oxydation.

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Occupational Health in India: Past, Present, Future

Summary

The provision of occupational health services in India is reviewed. At the present time, over 22 million workers are employed in some 135,000 factories, of which, only 2.5 per cent have more than 500 employees. Statutory legislation is restricted to safety and hygiene facilities, so few have sophisticated occupational health services. Dangerous industrial operations have been designated and notifiable diseases specified. Attention is drawn to the recommendations of the Association of Occupational Health, which require an improvement in legislation and an increase in public education of occupational diseases.

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India is a vast country with an area of 3,276,141 square kilometres and a population of 684 million. The city of Bombay alone has a population of about eight million. The climate varies from extreme heat in the south to extreme cold in the north.

Industrial Development

1. Past

During the last two centuries, India lagged very much behind the western world in respect of industrial development, though it was far advanced in the artistic skill of its craftsmen. Most of its manufactured requirements were imported from the western countries. The beginning of the 20th century saw a few industries being introduced and expanding, but vigorous development started only during the world wars, e.g. in textile, cement, paper, chemicals, steel and light engineering industries, etc. as a result of wartime import restrictions.

Many industries did not provide any medical service at the place of employment. Some provided first aid for their workers either by a trained first aider or a doctor on call. A few industries that were situated in remote places, where there were no hospitals, did organize some sort of medical service by appointing a doctor. This was mainly for curative aid for their employees, though some large industries set up small hospitals to provide treatment for the workers and their families.

2. Present

Planned industrial development started mainly about two to three decades ago in the fields of petroleum products, chemicals and chemical products, fertilizers, steel industries, mechanical and electrical equipment, power generation and atomic energy.

The working population in the rural areas is now about 216 million and, in the urban region, about 45 million.

The total number of factories in 1979 was 135,175,

employing 22,294,000 workers. Eighty-nine per cent are small units employing less than 500. The largest industry is the textile industry.

Textile Industry	1,109,000 workers
Basic Metal Alloys	447,000 workers
Machinery, Tools	472,000 workers
Chemical and Chemical Products	428,000 workers
Mines	741,000 workers
Plantations (tea, coffee and rubber)	901,020 workers

The small scale factories contribute 60 per cent of the total industrial output. India has made rapid progress in the field of industrial development, but, unfortunately, equal attention and interest has not been given to protecting, maintaining and promoting the health of workers, with the result that workers are exposed to great risks from occupational hazards, e.g., accidents causing physical injuries, and occupational diseases.

The working environment is generally not ideal from the point of view of industrial hygiene, and workers are often exposed to considerable physical, chemical and other hazards. Heat and humidity are present during the greater part of the year. Exposure to dust, gases and fumes are a constant danger to workers' health, particularly in small unorganized operations.

Moreover, the general physical state of the average Indian worker cannot be considered to be equivalent to that of their counterparts in western countries. They are generally undernourished and underweight. Besides suffering from nutritional diseases, they are frequently exposed to epidemics of infectious diseases – cholera, typhoid, malaria, leprosy, etc., and suffer other general ailments, particularly gastrointestinal and respiratory diseases. All these factors affect their physical capacity for work and reduce the productive growth of the nation.

Occupational Health Services

Most industrial firms have only first aid centres and no occupational health departments. Regrettably, only some large, progressive Indian companies and some established with foreign collaboration practise the modern concept of occupational health service by undertaking medical examinations of prospective employees, insisting on periodical medical checks of those in service and advising management on environmental hygiene and the protective measures necessary to ensure the continued good health of all employees. The medical services of the majority of

establishments are restricted to providing first aid and elementary curative treatment.

Most industrialists have not yet appreciated the purpose and utility of an occupational health service. It is extremely difficult to convince them of this, and direct profit cannot be visibly demonstrated, though it might be possible to show increased productivity. The employees themselves are oblivious of their health needs and of the hazards to which they are exposed. Neither have the trade union leaders shown sufficient interest in the health and safety of the workers or insisted that management should provide a medical service for the protection of employees' health. A survey carried out some years ago showed that the number of medical personnel in industrial organizations fell far below the requirements. In 44,000 factories, employing more than four million people, there were only 700 full-time doctors and 200 part-time doctors. Many of these were concerned only with curative aid.

However, in recent years attitudes are changing, and the purpose of an occupational health service is slowly being realized by the more progressive industrial establishments. With respect to the provision of medical services, the *Factory Act* does not lay down specific functions for the medical department. It vaguely states that an Ambulance Room, under the supervision of a qualified medical person, should be provided for factories employing 500 or more persons.

Therefore, most factories do not employ a full-time doctor but engage one on a retainer basis who is usually called in for emergencies only. Some factories employ part-time doctors. Medium and small scale industries do not generally provide any medical service for their employees.

Legislation

The government of India enacted the *Factories Act* in 1922 and the *Indian Mines Act* in 1923. These laws dealt with the problems of working conditions, and though rudimentary in content, they did bring some relief to workers by regulating working hours and by introducing some minimum amenities of hygiene and safety at the workplace. Since the end of the Second World War, and following Independence, the government enacted comprehensive laws known as the *Factories Act of 1948*, with special chapters on health and safety. These regulations provide for general hygiene, cleanliness, ventilation, control of dust and fumes, guarding of machinery, etc.

Dangerous Operations

The government has designated a list of dangerous industrial operations (Table 1), with special provisions laid down for particular processes. It has also laid down a rule for the notification of poisoning or disease in any industry. The notifiable diseases are specified in Table 2.

Table 1

Section 87 of the Indian Factories Act, 1948, designates as dangerous the following operations when carried on in any factory.

1. Manufacturing of aerated waters and processes incidental thereto.
2. Electrolytic plating or oxidation of metal articles by use of electrolyte containing chromic acid or other chromium compounds.
3. Manufacture and repair of electric accumulators.
4. Glass manufacture.
5. Grinding or glazing of metals.
6. Manufacture and treatment of lead and certain compounds of lead.
7. Generation of gas from dangerous petroleum, as defined in Clause (b) of section 2 of the *Petroleum Act*, 1934.
8. Cleaning or smoothing of articles by a jet of sand, metal, shot or grit or other abrasive propelled by a blast of compressed air stream.
9. Liming and tanning of raw hides and skins and processes incidental thereto.
10. Manufacture of chromic acid or manufacture or recovery of the bichromate or sodium potassium or ammonium.
11. Manufacture or manipulation of nitro or amino compounds.
12. Handling and manipulation of corrosive substances.
13. Manufacture of bangles and other articles from cinematograph films, and toxic and inflammable solvent.
14. Processes involving manufacture, use or evolution of carbon disulphide and hydrogen sulphide.
15. Manufacture and manipulation of asbestos.
16. Compression of oxygen- and hydrogen-produced electrolytic process.
17. Manufacture and manipulation of manganese and its compounds.
18. Carbon disulphide plants.
19. Benzene.

Table 2 **List of Notifiable Diseases:**

1. Lead poisoning, including poisoning by any preparation or compound of lead or their sequelae
2. Lead tetraethyl poisoning.
3. Phosphorous poisoning or its sequelae.
4. Mercury poisoning or its sequelae.
5. Manganese poisoning or its sequelae.
6. Arsenic poisoning or its sequelae.
7. Poisoning by nitrous fumes.
8. Carbon bisulphide poisoning.
9. Benzene poisoning, including poisoning by any of its homologues, their nitro or amido derivatives or its sequelae.
10. Chrome ulceration or its sequelae.
11. Anthrax.
12. Silicosis.
13. Poisoning by halogens or halogen derivatives of the hydrocarbons of the aliphatic series.
14. Pathological manifestations due to –
    (a) radium or other radioactive substances;
    (b) X-ray.
15. Primary epitheliomatous cancer of the skin.
16. Toxic anaemia.
17. Toxic jaundice due to poisonous substances.
18. Oil acne or dermatitis due to mineral oils and compounds containing mineral oil base.
19. Byssinossis.
20. Asbestosis.
21. Occupational or contact dermatitis caused by direct contact with chemicals and paints. These are two types, and are primary irritants and allergic sensitizers.
22. Noise-induced hearing loss (exposure to high noise levels).

Though these laws are fairly comprehensive, their application and enforcement have often proven difficult because of inadequate resources, lack of trained personnel and lack of appreciation of the problem on the part of some employers. Consequently, exposure to industrial hazards and risks to the health of workers still continues, and, at times, rises to dangerous levels, particularly among the small, unorganized establishments that may not come within the purview of the *Factories Act*.

Government Institutions

Besides the above legislation for factories, the government has also established several institutions to undertake surveys and conduct research and training in occupational health and safety. They include the following:

1. The Central Labour Institute has various departments, e.g., Industrial Medicine, Ergonomics, Industrial Hygiene, Industrial Physiology, Psychology, Industrial Safety. The Institute also conducts training courses in these subjects.
2. The National Institute of Occupational Health has the following Divisions: Occupational Medicine, Occupational Hygiene, Occupational Physiology, Occupational Psychology, Occupational Pharmacology and Occupational Toxicology.
3. Industrial Toxicology Research Centre.
4. Central Public Health Environmental Health Institute.

In addition, there is a social security scheme, known as the Employee's State Health Insurance Scheme. This scheme mainly provides curative aid, but gives financial assistance when loss of wages, disablement, etc., occurs.

Occupational Health Training

Initially, there was only one institution in India that offered a course leading to a diploma in Industrial Health. Today, there are three more institutions conducting similar courses. Short training courses in the various disciplines of occupational health are being conducted by the Central Labour Institute. The Indian Association of Occupational Health has recommended that the universities introduce occupational medicine in both undergraduate and post-graduate courses.

Voluntary Institutions for Health and Safety

The Indian Association of Occupational Health (IAOH) was established in 1948. The association is not restricted to industrial physicians; it also accepts, as associate members, nurses, safety officers, personnel and labour officers, and others interested in the health and safety of industrial workers.

The aims of the association are (1) stimulation of enquiry and research into cause, treatment and prevention of industrial diseases; (2) guidance of industry with respect to problems of industrial medicine and hygiene on modern scientific principles; (3) to secure effective and complete organization of medical officers in industry; and

(4) to maintain liaison with national and international organizations interested in tackling industrial and occupational health problems.

The association has a membership of over 800 in nine branches spread all over India. A conference has been held each year since its inception. Some international conferences have also been arranged.

On behalf of the IAOH and the Indian Cancer Society, a Commission on Occupational Cancer has been set up to study the incidence of occupational cancers and the exposure of workers to carcinogenic chemicals. Though statistics on the number of workers exposed to carcinogens were collected, very few cases of occupational cancers have been detected. This is because, in diagnosed cancer patients, no detailed history of their exposure to carcinogens is established. An in-depth study of certain types of cancers that may be due to occupational exposures is now under way.

The association has also set up an 'Occupational Health Services Foundation' with the object of undertaking studies in safety and health hazards and to advise management and trade unions on occupational health, particularly in those industries that do not provide any health services.

There is also an organization known as the Council of Industrial Safety, which promotes safety education for workers and awards prizes for the highest reduction in accidents.

Occupational Disease and Accidents

Considering that Indian workers are exposed to numerous hazards in their working environment, one would expect that the incidence of occupational disease in India would be phenomenally high. Unfortunately, most of these diseases go undetected or unreported to the authorities concerned. There may be three reasons for this:

First, the lack of awareness or ignorance on the part of both the employer and workers. Second, the fear of the employers that the trade unions may demand more wages for hazardous operations and that the government might impose severe restrictions or order modifications in the factory that would entail additional financial outlay and result in erosion of profits. Third, the reluctance of employees to report any ill effects on their health because of fear of losing their jobs.

In spite of the safety regulations and the existence of voluntary agencies like the safety councils to implement them, the accident rates in India continue to be high. The reason for this is that some employers do not implement the safety rules. Thus there are many instances where

machinery is poorly guarded, housekeeping is bad and, generally, there is a deplorable lack of safety and protective equipment.

Workers are not properly trained in safety procedures. The compensation for temporary or permanent disability, or even death due to accidents, is very meagre when compared to that prevailing in the West. Compensation is paid in proportion to the loss of earning capacity. An amount of Rs.40,000 ($4,000) is payable in case of death.

Occupational Health – The Future

The gradual increase in literacy levels and the growing consciousness among the working class about their rights and privileges will have a far-reaching influence on future developments. The occupational health service of tomorrow will have to reflect effectively both the expectations of the working class and the values they ascribe to it.

The Association of Occupational Health has recommended that the government 1) make amendments to the *Factories Act* with respect to the compulsory appointment of medical officers in certain categories of factories, e.g., those where hazardous operations take place and those employing 500 or more workers; 2) provide occupational health services in such factories; and 3) increase the complement of the factory inspectorate so that the factory laws can be enforced. The association is also trying to educate employees, trade unions, managers and supervisors in the different types of occupational diseases incidental to different industries and to appreciate the utility and purpose of occupational health services in promoting and maintaining the highest physical, mental and social well-being of the working population. Health for all by 2000 AD, as declared at the International Conference on Primary Health Care at the Alma-Ata on September 12, 1978, is what the association hopes to achieve. The ideals of the association are best expressed in a quote from M.K. Gandhi, revered in India as the Father of the Nation.

"Do all the good we can
By all the means we can
At all the places we can
In all the ways we can
At all the times we can
To all the people we can
As long as ever we can."

Résumé

Cet article examine la prestation de services dans le domaine de la médecine du travail en Inde. Plus de 22 millions de personnes travaillent présentement dans quelque 135 000 usines dont 2,5 pour cent seulement comptent plus de 500 employés. Les mesures législatives étant restreintes aux seules installations ayant trait à la sécurité et à l'hygiène, très peu d'usines offrent des services perfectionnés en médecine du travail. On a prescrit des normes pour les activités dangereuses et on a identifié les maladies à déclaration obligatoire. L'article attire également l'attention sur les recommandations de l'Association of Occupational Health, qui demandent une amélioration des mesures législatives ainsi qu'une meilleure éducation du public quant aux maladies professionnelles.

Prof. Giovanni Loriga
Translated by
Massimo Bovenzi, M.D.

The Use of Pneumatic Hammers*

Summary

This is an English translation by M. Bovenzi, MD. of the original reports by Prof. G. Loriga on the health and working conditions of workers using pneumatic hammers in Italy. (Bulletin of the Labour Inspectorate (1911): 2, 35–60.) The occurrence of Raynaud's phenomenon is reported, together with tingling and numbness aggravated by a cold working environment. Such phenomena are considered to be functional in nature and attributable to the fatigue of heavy and prolonged work. Restrictions on tool weight, air pressure and tool use was advised.

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Introduction

Professor Loriga had already carried out a survey on the health and working conditions of the men who used pneumatic hammers on stone and marble blocks at some yards in Rome (see Appendix). In the light of the results he had presented, Professor Loriga was subsequently charged by the Ministry of Agriculture, Industry and Commerce to extend his investigation to all other possible uses of pneumatic hammers for processing stone, marble or metal materials.

Stone and Marble Processing

Besides the already mentioned yards in Rome, the survey covered eight marble yards in Carrara, two marble and hard stone workshops in Milan and a *botticino* yard at Mazzano (Brescia).

The daily working hours in all these yards range between eight and nine. The tools used by the workers are both manual hammers and mallets and pneumatic hammers. A total of 400 pneumatic hammers are in use in the yards involved in the survey. The working air pressure is kept at around three to four atmospheres.

The pneumatic hammers are of three types: (i) barrel-shaped chipping hammers without handle and throttle valve; (ii) chipping hammers with throttle valve; (iii) the so-called 'gun' hammers, equipped with closed or posteriorly open handles and throttle valves. The 'gun' hammer is the most widely used in the surveyed yards.

According to Professor Loriga's observations, the introduction of pneumatic hammers with handles brought about considerable improvements in the men's health and working conditions. The workers using chipping hammers with no handles are, in fact, compelled to hold the tool with their right-hand fingers (hand in the 'obstetric position'), the muscles of which have therefore to bear jolting and vibration. On the other hand, the 'gun' hammer is held in a full handgrip and made to lean on

* Professor Giovanni Loriga's second report to His Excellency the Minister of Agriculture and Commerce

the wrist-bones: the stress is therefore borne not only by the muscles of the fingers, but also by the arm and forearm. This delays the onset of local muscular fatigue, and, above all, prevents the digital symptoms deriving from ischemia provoked by the permanent muscular contraction: blanching, coldness and tingling, numbness and stiffness and more or less persistent and severe tremor.

The author suggests that the vibrations of pneumatic hammers are not to be regarded as harmful *per se*, i.e. they do not necessarily represent a new occupational pathogenic agent, but simply aggravate the workers' stress and fatigue. Hence, some changes in the men's working conditions should be enough to improve their health state. In particular, the author suggests the following measures, which a number of labour contracts envisage already: (1) The air pressure should not exceed 3.5 atm. (2) The hammer should never be above 1.5 kg in weight. (3) The workers should always wear padded gloves or be provided with pads thick enough to wrap their hands or the hammer. (4) The workers should alternate the use of pneumatic and manual hammers. (5) No worker should be compelled to operate a pneumatic hammer for longer than four consecutive hours or two two-hour shifts.

Metal Working

The author visited eight machine-shops in Milan and eight shipyards in Genoa, La Spezia and Leghorn. The number of working hours per day is 10 to 11, and usually the men are paid by piece-work. The pneumatic hammers used for metal working have open or closed handles and throttle valves and operate at air pressures from 4 to 6 atm. Hammers of different weights are used for different kinds of jobs: 2 to 3 kg for fettling, 4 to 7 kg for chipping, and up to 13 kg for riveting. The author describes here a number of different applications of pneumatic hammers in metal working, such as: (a) cleaning of boilers and old iron constructions and fettling of iron castings; (b) iron, cast iron and steel chipping or cutting; (c) plate caulking; (d) plate riveting.

Besides the hammers, metal workers employ other pneumatic tools, e.g. air drills, pneumatic grinders and sandrammers.

From a clinical viewpoint, the author has observed that strong, muscular men with a highly resistant nervous system can bear the use of pneumatic hammers for a longer time. Many workers, however, need long and frequent pauses, and others give up this kind of job

saying that the hammer vibrations give them stomach-ache, make them restless and nervously wakeful and cause their arms to ache permanently. Metal workers do not, however, suffer from the ischemic symptoms of the fingers that affect the marble and stone workers in Rome, and this is probably due to a different way of holding the hammer.

In the light of such observations, the author then suggests that the vibrations of pneumatic hammers do not affect the human body directly, but rather aggravate the state of muscular fatigue determined by both the working conditions and the subject's own physical structure. For example, the author has observed that the men using pneumatic hammers for metal working are in better health than those who operate them on marble and stone. This difference could be ascribed to the following factors: (1) The working of metals requires less muscular effort than marble and stone chipping; (2) the amplitude of the oscillations generated by iron and steel chipping is less than that generated by stone cutting; (3) the pneumatic hammers used for metal working are of better technological quality; (4) vibration exposure in metal working is intermittent, i.e. relieved by frequent resting intervals; (5) in metal working special implements are used for extremely heavy jobs or for jobs requiring awkward attitudes. Some examples are: the arched riveter, a two-wheel trolley with a shaft onto which the hammer can be screwed, the hammer for riveting in narrow spaces, the riveters for ships' outer shells.

In conclusion, the present survey on pneumatic hammers has actually revealed that operating these tools involves a higher degree of fatigue than does using manual ones. This does not, however, necessarily imply the use of vibrating tools ought to be forbidden; their introduction has undoubtedly brought about productivity increases and improved job quality. Nevertheless, the working conditions must be thoroughly surveyed, taking into due account the fact that the use of pneumatic hammers should never exceed the men's physical resistance. In particular, such factors as the number of working hours and the workers' wages, the nature of the worked materials, the technical specifications of vibrating tools, the air pressure and the worker's posture on the job are of the utmost importance.

Appendix

Professor Giovanni Loriga's first report to His Excellency the Minister of Agriculture, Industry and Commerce about the use of pneumatic hammers by stonecutters.

The aim of the present study is to investigate the working conditions of stonecutters in the marble and stone yards in Rome. These men use pneumatic hammers to carve building stones and marble blocks. About 200 workers are employed in the yards, and their exposure time to vibrating tools ranges from a few months to more than three years. They work eight hours a day scabbling blocks and carving or finishing marble items. Their pneumatic hammers consist of 12 to 20-cm-long metal barrels, 2 to 3.5 cm in diameter, with no handles or throttle valves. Their weight ranges between 0.7 and 1.5 kg, and the air pressure from 3.5 to 5 atm. The hammer repetition rate is of at least 1,000 strokes/min.

The worker holds the barrel with his right-hand fingers and drives the chisel with the left. The tool vibrations are therefore transmitted to both his arms, and can be felt up to the left-arm elbow and the right shoulder. To attenuate the vibration transmission, the workers wear cloth-lined leather gloves or wrap the hammer barrel in wool. As to the possible harm pneumatic hammers can do to the workers' health, the men complained first of a feeling of awkwardness in their hands. Later, their fingers tingle and become white, stiff and numb (the left-hand distal phalanges in particular). Tingling and numbness develop especially when a cold working environment adds its effects to those of the vibrations. The blanching of the fingers is of extremely short duration and is immediately followed by mild hyperaemia and a feeling of heat. A worker reports a friend of his – who has been working in the U.S.A. for five years now – actually lost sensitivity in his distal phalanges. He also says this phenomenon is quite frequent in the U.S. among men using pneumatic hammers.

None of the workers in Rome, however, presented such severe symptoms. Most of them do not believe pneumatic hammers to be more fatiguing and potentially harmful than manual hammers and mallets. Some groups of men, however, complain that the use of pneumatic hammers not only induces the above-mentioned local symptoms but is also the cause of some general conditions such as: insomnia, restlessness, irritability, moodiness, digestive symptoms, stomach-ache, nausea and fits of headache. The clinical examination revealed a slight tremor of the hands (particularly the right) and some blanching and coldness of the distal phalanges (of the left hand especially). No remarkable alteration in the sensitivity to touch and pain or in muscular strength was observed, however. The tremor and blanching of the

fingers are regarded as functional phenomena. In particular, the tremor can be interpreted as a transient manifestation of muscular fatigue due to extreme and prolonged effort; whereas the local ischemia can be due to a vasoconstriction produced by either the muscular contractions or excitement of the reflex arch. Since, however, the finger ischemia is of a transient nature, the author does not regard the use of pneumatic hammers as likely to induce severe circulatory disorders resulting in tissue gangrene (Raynaud's disease) or permanent anatomical injuries to sensory and motor nerves.

As a rule, the author does not consider the local and general symptoms affecting stonecutters to be a sign of nervous or muscular organic lesions, nor are they to be regarded as typical manifestations of a new pathogenic agent, i.e. the hammer vibrations. Rather, such phenomena are of a functional nature and should therefore be ascribed to the fatigue of heavy and prolonged work. In particular, the fatiguing effects of pneumatic hammers are due to a combination of three factors: muscular contraction, noise and the mental concentration effort. Moreover, the weaker the individual's resistance, the earlier and more severe the onset of fatigue symptoms. The differences in muscular and nervous resistance between the men do, in fact, account for both the presence or absence of symptoms and the variety of local and general phenomena. Nevertheless, the author concludes that, at the present stage of medical knowledge, one cannot, with certainty, rule out the possibility that more severe organic or functional disorders might develop in the future, i.e. neuralgias or paretic-spastic episodes resembling those we already know as writer's and piano-player's cramps.

Résumé

Cet article est une traduction vers l'anglais, par le docteur M. Bovenzi, des comptes rendus du professeur G. Loriga sur les conditions de travail et l'état de santé des travailleurs qui se servent de marteaux pneumatiques en Italie (Bulletin of the Labour Inspectorate (1911): 2, 35–60). On y signale l'existence du syndrome de Raynaud, qui s'accompagne de sensations de picotement et d'engourdissement aggravées par un milieu de travail froid. On estime que de tels phénomènes sont à caractère fonctionnel et qu'ils sont attribuables à de gros travaux prolongés qui accroissent le stress et la fatigue des travailleurs. On recommande l'adoption de restrictions en ce qui a trait au poids et à l'utilisation des outils ainsi qu'à la pression de l'air comprimé.

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News and Notes

Eighth Annual Workshop in Industrial Hygiene

The Eighth Annual Workshop in Industrial Hygiene, to be held at the University of Toronto, is designed for professional occupational hygienists who, perhaps as a result of specialization, feel the need for a general refresher course, for recent entrants to the hygiene field who wish to broaden their background knowledge and for management, safety professionals and labour representatives who wish to acquire a rapid understanding of industrial hygiene.

The workshop is organized by the Department of Chemical Engineering and Applied Chemistry and will be held Monday, September 29 through Friday, October 3, 1986. The panel of lecturers includes Dr. John Steel, Dip.Occ.Hyg., of Newcastle-upon-Tyne, United Kingdom, personnel from the Ontario Ministry of Labour, and Faculty and Staff of the University of Toronto. The expertise of the 18 speakers covers all relevant aspects of hygiene, risk assessment, human factors engineering, toxicology, occupational medicine and occupational health and safety legislation. A hands-on equipment demonstration is included in the workshop. The problem of coping with Ontario's designated substances will be specifically addressed.

The Industrial Hygiene and Hazard Control Engineering Program of the University of Toronto is presenting the workshop in association with the Occupational and Environmental Health Unit, Faculty of Medicine, University of Toronto and the Industrial Accident Prevention Association of Ontario. Professor J.W. Smith, Ph.D., C.Eng., C.I.H., Chairman of the Department of Chemical Engineering and Applied Chemistry, is Program Director.

Enquiries should be addressed to:
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(416)978-3066

Coming Events

August 3 – 9, 1986	International Symposium on Natural and Man-Made Hazards. RIMOUSKI, QUEBEC, CANADA. For further information, contact: Dr. Mohammed El-Sabh, Département d'Océanographie, Université du Québec à Rimouski, 310, avenue des Ursulines, Rimouski, Quebec G5L 3A1. (418) 724-1755
August 10 - 14, 1986	International Conference on Safety and Health at Work, ADELAIDE, SOUTH AUSTRALIA. For further information contact: Mr. Bill Embling, Conference Secretariat, 'Safety and Health at Work' Conference, GPO Box 465, Adelaide, 5001, South Australia.
September 15 - 19, 1986	Fifth International Symposium on Loss Prevention and Safety Promotion in the Process Industries. CANNES, FRANCE. For further information contact: Societe de Chime Industrielle, 28 Rue Saint-Dominique, 75007 Paris, France.
September 16 - 19, 1986	Medichem '86 Fourteenth International Congress on Occupational Health in the Chemical Industry. LUDWIGSHAFEN, GERMANY. For further information contact: Professor A.M. Thiess, Corp. Medical Director, Basf, Aktiengesellschaft, D-6700, Ludwigshafen, FRG.
September 28 - October 1, 1986	2nd International Conference on the Combined Effects of Environmental Factors, KANAZAWA, JAPAN. For further information contact: Conference Secretariat, c/o Department of Public Health, School of Medicine, Kanazawa University, 13-1 Takaramachi, Kanazawa, 920 Japan
September 29 - October 3, 1986	15th Annual Ontario Occupational Health Nurses Association – 'Conference '86', SUDBURY, ONTARIO, CANADA. For further information contact: Ms. J. Martindale, Conference '86, c/o INCO Limited, 38 Godrey Drive, Copper Cliff, Ontario, P0M 1N0.

October 8 - 10, 1986	International Conference: Occupational and Environmental Significance of Chemical Carcinogens. BOLOGNA, ITALY. For further information contact: M.A. Mehlman, North American Regional Secretariat, 7 Bouvant Drive, Princeton, New Jersey, 08540
October 20 - 22, 1986	Frontier Health and Safety, Ottawa Congress Centre, OTTAWA, ONTARIO, CANADA. For further information contact: Mr. K.A. Oakley, First National Health and Safety Symposium, P.O. Box 5218, St. John's, Newfoundland, Canada, A1C 5W1 (709) 726-7270
May 4 - 6, 1987	International Conference on Occupational Health and Safety, McMaster University, HAMILTON, ONTARIO, CANADA. For further information contact: Mrs. P.M. Yake, McMaster University, Health Sciences Centre, Room 3 H 50, 1200 Main Street West, Hamilton, Ontario, L8N 3Z5.
May 24 - 30, 1987	ILO's 11th World Congress on the Prevention of Occupational Accidents and Diseases 'Co-operation Towards a Better Working Environment: The Future of Safety and Health at Work' STOCKHOLM, SWEDEN. For further information contact: Swedish Organizing Committee, Post Box 22236, S-104 22, Stockholm, Sweden.
September 27 - October 2, 1987	XXII International Congress on Occupational Health. SYDNEY, AUSTRALIA. For further information contact: The Secretariat, XXII International Congress on Occupational Health. G.P.O. Box 2609. Sydney, N.S.W., Australia 2001.

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